[Claims]

[Claim 1]

A method, for forming, on a substrate, a layer having a predetermined plane pattern, characterized by comprising the steps of:

preparing an expanded pattern by outwardly extending outer edges of a closed area that constitutes a plane pattern to be formed, and preparing a lithographic plate for printing said expanded pattern;

preparing a resist agent wherein material particulates, which are to be made into a layer, are dispersed in a photosensitive resin;

employing said prepared resist agent as ink and said prepared lithographic plate as a plate to perform printing in order to form, on said substrate, a paste layer that is made of said resist agent;

employing a photomask having a plane pattern to expose said paste layer;

developing said paste layer that has been exposed, and removing a portion outside said outer edges of said closed area that constitutes said plane pattern; and

annealing a remaining portion of said paste layer and removing a resin portion to form a layer made of said material particulates.

[Claim 2]

A method according to claim 1 for forming a layer having a predetermined plane pattern, whereby a resist

agent where metal particulates are dispersed in a photosensitive resin, or a resist agent wherein organic metal is mixed with a photosensitive resin, is employed as said resist agent, and a conductive layer having said predetermined plane pattern is formed.

[Claim 3]

A method according to claim 1 for forming a layer having a predetermined plane pattern, whereby a resist agent wherein insulating particulates are dispersed in a photosensitive resin is employed as said resist agent, and an insulating layer having said predetermined plane pattern is formed.

[Claim 4]

A method according to one of claims 1 to 3 for the first to the third aspects for forming a layer having a predetermined plane pattern, whereby a plurality of paste layers are formed by employing different resist agents, and are exposed at the same time by employing the same photomask.

[Detailed Description of the Invention]

[0001]

[Technical Field to which the Invention Belongs]

The present invention relates to a method for forming a layer having a predetermined plane pattern, and relates in particular to a method whereby a paste layer is formed by using a resist agent obtained by dispersing material particulates in a photosensitive resin, and

whereby the paste layer is exposed and developed, and thereafter, a layer having a predetermined pattern is formed by the annealing process.

[0002]

[Prior Art]

Multiple layers including various types of plane patterns are formed on substrates constituting various integrated circuits and display devices. Since the layers used for an integrated circuit or a display device have very fine patterns, these layers are generally formed by the photolithography method. For example, as a method for forming a fine electrode layer, there is a well known method whereby a metal layer is formed on a substrate by the sputtering method or the evaporation method, and is patterned. That is, after a metal layer is formed on the substrate by the sputtering method or the evaporation method, a resist layer is formed on the metal layer, and is exposed by using a predetermined photomask. Then, the resist layer is developed to expose one part of the metal layer, the exposed portion is removed by etching or sandblasting, and the resist layer is parted. As a result, the metal layer having a predetermined plane pattern can be obtained. However, according to this method, until the layer having a predetermined plane pattern is obtained, multiple steps are required: a metal layer forming step, a resist layer forming step, a resist layer exposure and developing step, an etching or sandblasting step and a

resist layer parting step.

[0003]

There is also another well known method for employing a so-called "paste layer" to form a layer having a predetermined plane pattern. For example, to form a metal layer, a "metal paste" wherein metal particulates are dispersed in a photosensitive resin is prepared, and is coated on the substrate, the resultant substrate is exposed by using a predetermined photomask, the paste layer is developed and partially removed, and the remaining paste layer is annealed to remove the resin. As a result, a metal layer can be obtained. According to the method employing the "metal paste", since the paste layer functions as a photosensitive resist, only the paste layer forming step, the paste layer exposure and developing step and the annealing step need only be performed to obtain a thin film electrode having a predetermined pattern. Thus, as the advantage, the number of manufacturing steps can be reduced compared with the above described general patterning method. When an "insulating paste" obtained by dispersing insulating particulates in a photosensitive resin is employed, an insulating layer can also be formed.

[0004]

[Problems to be solved by the Invention]

As is described above, when a layer having a predetermined plane pattern is to be formed on a substrate, according to a general method, a predetermined material

layer or a paste layer is formed on the substrate, and an unnecessary portion is removed at the exposure and developing step. According to this method, naturally, at the developing step, an unnecessary portion is melted into a developer and is removed from the substrate. That is, the material used for the removed portion is wasted. The waste of the material is not a big problem to form a layer made of a comparatively inexpensive material such as aluminum; however, to form a layer made of a noble metal such as gold or platinum, the rate of the material expense to the entire manufacturing cost is fairly high, so that the waste of the material becomes a serious problem.

[0005]

Recently, the demand on a flat panel display has been increased, and devices, such as PDP (Plasma Display Panel) and an FED (Field Emission Display) have been practically used. In these display devices, since light is generated through emission of electrons from fine pixel electrodes, a fine electrode layer made of a less deteriorated material, such as gold or platinum, must be formed. In addition, large power consumption is required for the display devices, and to manufacture a large screen display, a delay due to the increase of the length of wiring need be prevented. Because of this reason, an expensive material such as gold or platinum is also demanded to form a layer. As is described above, when a layer is to be formed by using an expensive material such

as gold or platinum, an unwanted material expense is necessary for the conventional method, and the increase of the manufacturing cost can not be avoided.

[0006]

It is, therefore, one objective of the present invention to provide a method for forming a layer having a predetermined plane pattern, while avoiding the waste of a material as much as possible.

[0007]

[Means for Solving the Problems]

(1) According to a first aspect of the present invention, provided is a method, for forming, on a substrate, a layer having a predetermined plane pattern, comprising the steps of:

preparing an expanded pattern by outwardly extending outer edges of a closed area that constitutes a plane pattern to be formed, and preparing a lithographic plate for printing the expanded pattern;

preparing a resist agent wherein material particulates, which are to be made into a layer, are dispersed in a photosensitive resin;

employing the prepared resist agent as ink and the prepared lithographic plate as a plate to perform printing in order to form, on the substrate, a paste layer that is made of the resist agent;

employing a photomask having a plane pattern to expose the paste layer;

developing the paste layer that has been exposed, and removing a portion outside the outer edges of the closed area that constitutes the plane pattern; and

annealing a remaining portion of the paste layer and removing a resin portion to form a layer made of the material particulates.

[0008]

(2) According to a second aspect of the present invention, for the method of the first aspect for forming a layer having a predetermined plane pattern, a resist agent where metal particulates are dispersed in a photosensitive resin, or a resist agent wherein organic metal is mixed with a photosensitive resin, is employed as the resist agent, and a conductive layer having the predetermined plane pattern is formed.

[0009]

(3) According to a third aspect of the present invention, for the method of the first aspect for forming a layer having a predetermined plane pattern, a resist agent wherein insulating particulates are dispersed in a photosensitive resin is employed as the resist agent, and an insulating layer having the predetermined plane pattern is formed.

[0010]

(4) According to a fourth aspect of the present invention, for the method for the first to the third aspects for forming a layer having a predetermined plane pattern, a

plurality of paste layers are formed by employing different resist agents, and are exposed at the same time by employing the same photomask.

[0011]

[Mode for carrying out the Invention]

The present invention will now be described by referring to illustrated mode. First, while referring to cross-sectional views in Figs. 1 to 3, an explanation will be given for a pattern formation method employing a conventional common "paste layer". First, a resist agent is prepared by dispersing, in a photosensitive resin, material particulates that are to be made into a layer, and is coated on the overall surface of a substrate 10. The resist agent is a paste, and a paste layer 20 as shown in Fig. 1 is formed on the substrate 10. Then, as is shown in Fig. 2, the paste layer 20 is exposed by using a photomask 30 having a predetermined pattern. As a result, a portion of the paste layer 20 that has been irradiated becomes an exposed portion 20a, while a portion that is not irradiated becomes an non-exposed portion 20b. Sequentially, the paste layer 20 is developed. When a negative resin is employed as the photosensitive resin, the paste layer 20 functions as a negative resist, and the non-exposed portion 20b is removed through the developing process. As a result, as is shown in Fig. 3, only the exposed portion 20a is maintained as a remaining layer. Thus, when the remaining exposed portion 20a is annealed at a predetermined

temperature, the resin element is evaporated, and a predetermined pattern made of the material particulates is obtained. When a positive resin is employed as the photosensitive resin, a positive/negative inverted pattern layer is obtained.

[0012]

As is described above, according to the patterning method employing the "paste layer", since the "paste layer" functions as both a resist layer and a material layer, there is an advantage obtained that the total number of steps is reduced, compared with a general patterning method whereby a resist layer is separately formed on a material layer. However, the operation for "removing an unnecessary portion at the exposure and developing step" is still required as well as for the other conventional patterning methods. For example, at the above described step, the non-exposed portion 20b of the paste layer 20 is removed by developing. When, for example, a "gold paste" obtained by dispersing metal particulates in a photosensitive resin is employed, a large amount of gold is abandoned in a developer. While taking into account a considerably high cost for a gold material, a large amount of the material expense is wasted, and this waste is a large problem for reduction of the manufacturing cost. According to the present invention, an innovative method is provided to avoid the waste of the material as much as possible.

[0013]

The basic concept of the present invention will now be described based on a specific mode. Assume that a layer 40 having a plane pattern P1 as is shown in a plan view in Fig. 4 is to be formed on a substrate. In this case, the outer edges of a closed area that constitutes the plane pattern P1 to be formed are extended outward by a distance d, and an expanded pattern P2 shown in Fig. 5 is prepared. That is, the expanded pattern P2 can be said as a pattern that is one size larger than the original plane pattern P1. Then, a lithographic plate is prepared to print the expanded pattern P2. Further, a resist agent is prepared by dispersing, in a photosensitive resin, material particulates that are to be made into a layer. While the resist agent is employed as ink and the prepared lithographic plate is employed as a plate, printing is performed to form, on the substrate, a paste layer 45 that is made of the resist agent. Fig. 5 is a plan view of the paste layer 45, and a broken line indicates the original plane pattern P1. As is shown in Fig. 5, the external shape pattern of the paste layer 45 is the expanded pattern P2 obtained by enlarging the original plane pattern P1 by the distance d. Since the paste layer 45 is obtained at the printing step, an advanced pattern formation technique is not required, and a comparatively low cost step can be employed. On the other hand, high positioning accuracy can not be obtained.

[0014]

Sequentially, the paste layer 45 is exposed by using a photomask having a predetermined plane pattern P1, as is shown in a plan view in Fig. 4. Fig. 6 is a plan view of the post-exposed state when a paste containing a negative photosensitive resin is employed. In this case, the exposure process using the photomask is performed, so that the portion inside the outer edges of the closed area that constitutes the plane pattern P1 becomes an exposed portion 45a, and the portion outside the outer edges becomes a non-exposed portion 45b. This exposure step is a general photolithography step, and high positioning accuracy can be obtained. Thereafter, when the exposed paste layer 45 is developed, and the non-exposed portion 45b is removed, as is shown in a plan view in Fig. 7, only the exposed portion 45a is maintained as a remaining layer. In other words, the portion outside the outer edges of the closed area that constitutes the plan pattern P1 is removed. Finally, the resin element is removed by annealing the remaining paste layer (exposed portion 45a), and a layer having the predetermined pattern P1 made of the material particulates is obtained.

[0015]

When a paste containing a positive photosensitive resin is employed for the paste layer 45, the exposure process using a photomask need only be performed, so that the portion inside the outer edges of the closed area that constitutes the plane pattern P1 becomes a non-exposed

portion, and the portion outside the outer edges becomes an exposed portion. Also in this case, the portion outside the outer edges of the closed area that constitutes the plane pattern P1 is removed at the developing step.

[0016]

In conclusion, the main point of the present invention is that, instead of coating a paste layer on the overall surface of the substrate, a paste layer having the expanded pattern P2 that is slightly larger than the predetermined plane pattern P1 is formed by printing. The succeeding exposure and developing step is performed thereinafter in the same manner as the conventional method. This process will be described while referring to the cross-sectional views. First, as is shown in Fig. 8, the paste layer 45 is formed on the substrate 10 by printing. In Fig. 8, a portion indicated by a broken line corresponds to the original plane pattern P1, and the pattern for the paste layer 45 is the expanded pattern P2 obtained by outwardly extending, by the distance d, the outer edges of the closed area that constitutes the plane pattern P1. Sequentially, as is shown in Fig. 9, the paste layer 45 is exposed by using the photomask 30 having the plane pattern P1, the exposed portion 45a and the non-exposed portion 45b are obtained, and the non-exposed portion 45b is removed by developing (a case of a paste that contains a negative photosensitive resin). When the amount of the paste layer that is lost by developing is focused on, a large portion,

i.e., the non-exposed portion 20b, is lost by the conventional method in Fig. 2, while only the non-exposed portion 45b is lost by the method of the present invention shown in Fig. 9. As is apparent, according to the method of the present invention, the unnecessary portion removed by the developing is reduced as much as possible. Therefore, when a paste containing expensive particulates, such as gold particulates, is employed, the waste of the material expense can be reduced to the minimum.

[0017]

The distance d between the outer edges of the plane pattern P1 to be formed and the outer edges of the expanded pattern P2 should be set as an optimal value, while taking into account a aligning difference at the printing step. Specifically, when the aligning difference at the printing step is Δ, d need be set to establish $\Delta < d$. Since the waste of the material expense is increased as d is large, theoretically, the d need be set so as to establish $\Delta = d$. However, actually, since a variance occurs in the aligning difference Δ, it is preferable that d be set with some allowance. The feature of the present invention is that the rough expanded pattern P2 is formed at the printing step for which the positioning accuracy is comparatively low, and then, the accurate plane pattern P1 is formed at the photolithography step for which the positioning accuracy is comparatively high. Therefore, the distance d between the outer edges of the plane pattern P1

and the outer edges of the expanded pattern P2 need only be a distance to sufficiently cover the aligning difference at the printing step. At the printing step, a general printing method, such as screen printing or offset printing, can be employed.

[0018]

Further, the same value of d need not be employed for the entire periphery along the outer edges, and may differ depending on the positions so long as the value of d is larger than the aligning difference Δ at the printing step. Therefore, while the expanded pattern P2 in Fig. 5 is a similar figure to the original plane pattern P1, the expanded pattern need not always be a similar figure to the original plane pattern, and, for example, relative to a cross-shaped plane pattern, a rectangular pattern completely covering this pattern may be employed as an expanded pattern. In order to efficiently reduce the waste of the material expense, however, it is preferable that an expanded pattern that is employed be close to a similar figure.

[0019]

In the above described mode, the present invention is applied for a case of forming a single layer. However, the present invention can also be applied for a case of forming multiple layers at the same time. Specifically, a plurality of paste layers of different resist agents are formed, and are exposed by using the same photomask at the

same time. As a result, a plurality of layers can be obtained at the same time. This process will be explained while referring to the cross-sectional views in Figs. 10 to 12. First, as is shown in Fig. 10, a first paste layer 51 is formed on a substrate 10 by printing. Then, as is shown in Fig. 11, a second paste layer 52 is formed on the first paste layer 51 by printing. Since these layers are obtained by printing, the positioning accuracy is comparatively low. Following this, as is shown in Fig. 12, the first and second paste layers 51 and 52 are exposed by using a photomask 30 having a predetermined pattern (a pattern one size smaller than the patterns for the first and the second paste layers 51 and 52), so that the portions of the paste layers 51 and 52 that are irradiated become exposed portions 51a and 52a, and the portions that are not irradiated become non-exposed portions 51b and 52b.

[0020]

At this time, when the paste layers 51 and 52 contain a negative photosensitive resin, the non-exposed portions 51b and 52b are removed by developing, and as is shown in Fig. 13, the exposed portions 51a and 52a remain. When the exposed portions 51a and 52a are annealed, two layers having the same plane pattern can be obtained at the same time. However, when a plurality of layers are to be patterned at the same time, the layers other than the bottommost layer (or layers other than the topmost layer when back exposure is performed from downward the substrate

10) must be formed of a light-transmitting material.

[0021]

A plurality of layers formed by this method do not always have the same plane pattern. For example, assume that, as is shown in Fig. 14, the first paste layer 51 is printed on the substrate 10, and then, a second paste layer 53 is printed on the first paste layer 51. In this case, as is shown in Fig. 15, the paste layers 51 and 53 are exposed by using the photomask 30 having a predetermined pattern, so that the portions of the paste layers 51 and 53 that are irradiated become exposed portions 51a and 53a, and the portions that are not irradiated become non-exposed portions 51b and 53b. When the non-exposed portions 51b and 53b are removed by developing, the exposed portions 51a and 53a remain. By annealing these layers, two layers having different plane patterns can be obtained. In this case, since one end of the upper layer (left end of the exposed portion 53a in Fig. 15) is obtained at the printing step, the positioning accuracy is comparatively low. However, this method is a sufficiently practical, double-layer forming method in order to form the end face for which the high positioning accuracy is not required.

[0022]

[Embodiments]

An explanation will now be given for an example wherein the present invention is applied for specific embodiments. In the explanation for the embodiments, the

present invention is applied for a process for manufacturing a matrix substrate used for an FED (Field Emission Display). Multiple electrode emitting devices are arranged vertically and horizontally on the matrix substrate, and light emission for one pixel is obtained by emitting electrons from one electron emitting device. In the following explanation, for the sake of convenience, a step of forming an electron emitting device for one pixel is shown in the drawings; however, actually, electron emitting devices for multiple pixels are formed at the same time.

[0023]

<First Embodiment>

As is shown in Fig. 16, by using a photosensitive resin wherein gold particulates of the size of 2 nm to 1 μm are dispersed, the overall surface of a clean silica glass substrate 100 of 3 mm thick is printed by a screen printing, and a preparation layer 105 is obtained. The resultant substrate is placed in an oven at 80°C for thirty minutes to dry the preparation layer 105, and an organic metal thin film layer of 7 μm thick is obtained. After the resultant structure is cooled, the preparation layer 105 is exposed by using a photomask having a predetermined pattern (the pattern of a lower electrode layer 110 that will be described later), and then, is developed. The obtained substrate is annealed in a furnace at 400°C for two hours to remove the organic element. Then, as is shown in Fig.

17, the lower electrode layer 110 made of gold of 3 μm thick is obtained.

[0024]

Sequentially, by the screen printing method, a predetermined expanded pattern is printed by employing, as ink, a resist agent made of a negative photosensitive resin in which glass particulates having the size of about 2 nm to 1 μm are dispersed. Thus, a preparation layer 125 as is shown in Fig. 18 is obtained. The entire structure is placed in the oven at 80°C for thirty minutes, and a preparation layer 125 of 45 μm thick is obtained. After the substrate is cooled, as is shown in Fig. 19, the preparation layer 125 is exposed by using a photomask M having a predetermined pattern (the pattern of an insulating layer 120 that will be described later), and is developed. The resultant substrate is annealed in a furnace at 500°C for three hours to remove the organic elements. Thus, as is shown in Fig. 20, the insulating layer 120 containing glass of 22 μm thick is formed.

[0025]

After the obtained substrate is cooled, by the screen printing method, a predetermined expanded pattern is printed employing, as ink, a resist agent that is made of a negative photosensitive resin in which gold particulates having the size of 2 nm to 1 μm are dispersed. Thus, as is shown in Fig. 21, a preparation layer 135 is formed. The entire substrate is placed in the oven at 80°C for thirty

minutes to dry the preparation layer 135, and an organic metal thin film layer of 7 μm thick is obtained. After the substrate is cooled, as is shown in Fig. 22, the preparation layer 135 is exposed by using a photomask M having a predetermined pattern (pattern for an upper electrode layer 130 that will be described later (in this embodiment, the pattern for the upper electrode layer 130 is the same as the pattern for the insulating layer 120)), and is developed. The resultant substrate is annealed in a furnace at 400°C for two hours, the organic elements are decomposed and removed, and as is shown in Fig. 23, the upper electrode layer 130 that is 3 μm thick and is made of gold is obtained.

[0026]

Following this, by the screen printing method, an organic solvent containing an organic palladium compound ("catapaste CCP" manufactured by Okuno Pharmaceutical Industry Co., Ltd.) is printed on the side face of a three-layer structure formed of the lower electrode layer 110, the insulating layer 120 and the upper electrode layer 130. The resultant structure is left as it is for fifteen minutes, and is thereafter annealed at about 200°C for twenty minutes, and as is shown in Fig. 24, an electron emitting film 140 made of a Pb particulate layer is formed. In this case, the three-layer structure, which is formed of the lower electrode layer 110, the insulating layer 120 and the upper electrode layer 130, and the electron emitting

film 140, which is formed on the side face, constitute an electron emitting device 200, as will be described later.

[0027]

In Fig. 24, only one electron emitting device 200 is shown. However, actually, multiple electron emitting devices 200 are arranged on the substrate 100 in a matrix shape, and the lower electrode layer 110 is used as a common electrode extended in the direction of columns, while the upper electrode layer 130 is used to as a common electrode extended in the direction of rows.

[0028]

In the above described manufacturing process, at the step of forming the lower electrode layer 10, most part of the preparation layer 105 containing gold is removed, and gold used as the material is wasted. This is because, as is shown in Fig. 16, the preparation layer 105 is formed on the overall surface of the substrate. Whereas, at the step of forming the insulating layer 120, as is shown in Fig. 18, the preparation layer 125 is printed using a predetermined pattern, so that the waste of glass particulates contained in the material for the preparation layer 125 can be considerably avoided. Further, at the step of forming the upper electrode layer 130, as is shown in Fig. 21, the preparation layer 135 is printed using a predetermined pattern, so that the waste of gold particulates contained in the material for the preparation layer 135 can be considerably avoided.

[0029]

In the above described embodiment, an example has been explained wherein the present invention is applied for the process for forming the insulating layer 120 and the process for forming the upper electrode layer 130, and it is represented that the present invention can be applied for formation of both an insulating layer and a conductive layer. Practically, it is preferable that the present invention be employed for the process for forming the lower electrode layer 110 and the upper electrode layer 130 that are made of gold.

[0030]

<Second Embodiment>

In this embodiment, a lower electrode layer 110 is formed by the sputtering method, and an insulating layer 120 and an upper electrode layer 130 are formed by using a simultaneous multi-layer exposure method. First, as is shown in Fig. 16, a Cr preparation layer 105 of 3 μm thick is deposited on a clean silica glass substrate 100 of 3 mm thick by the sputtering method. Then, a resist agent ("ORM85" manufactured by Tokyo Applied Chemistry Industry Co., Ltd.) is coated on the substrate by a spinner, and the resultant substrate is placed in an oven at 80°C for thirty minutes until it is dried. After the substrate is cooled, the resist layer is exposed by using a photomask having a predetermined pattern (pattern for a lower electrode layer 10), and is developed and cleaned with water. Following

this, the substrate is placed in the oven at 135°C for thirty minutes, and after the substrate is cooled, the exposed portion of the Cr preparation layer 105 is etched and removed by using a Cr etching liquid ("MR-DS" manufactured by Tokyo Applied Chemistry Industry Co., Ltd.). Thereafter, the substrate is cleaned with water.

[0031]

Sequentially, the whole substrate is immersed in a resist parting liquid ("Clean Stop" manufactured by Tokyo Applied Chemistry Industry Co., Ltd.) at 120°C for five minutes, and is thereafter immersed in a stripping and rinsing liquid at a room temperature for one minute. Then, the substrate is immersed in isopropyl alcohol at a room temperature for one minute in order to part and remove the resist layer. When the resultant substrate is cleaned with water and dried, as is shown in Fig. 17, the lower electrode layer 110 that is made of Cr and is 3 μm is obtained.

[0032]

Sequentially, by the screen printing method, a predetermined expanded pattern is printed employing, as ink, a resist agent that is made of a negative photosensitive resin wherein glass particulates having the size of about 2 nm to 1 μm are dispersed. Thus, a preparation layer 125 as is shown in Fig. 18 is obtained. The entire structure is placed in the oven at 80°C for thirty minutes, and a preparation layer 125 of 45 μm thick is obtained. After

the obtained substrate is cooled, by the screen printing method, a predetermined expanded pattern is printed by employing, as ink, a resist agent that is made of a negative photosensitive resin in which gold particulates having the size of 2 nm to 1 μm are dispersed. Thus, as is shown in Fig. 25, a preparation layer 136 is obtained on the preparation layer 125. The entire substrate is placed in the oven at 80°C for thirty minutes, and the preparation layer 135 is dried to obtain an organic metal thin film layer of 7 μm thick.

[0033]

After the substrate is cooled, as is shown in Fig. 26, both the preparation layer 136 and the preparation layer 125 are exposed by using a photomask M having a predetermined pattern (pattern for an upper electrode layer 130), and are developed. The resultant substrate is annealed in a furnace at 400°C for three hours, the organic elements are decomposed and removed, and as is shown in Fig. 23, the gold upper electrode layer 130 of 3 μm thick and the insulating layer 120 of 25 μm thick are obtained.

[0034]

Following this, by the screen printing method, an organic solvent containing an organic palladium compound ("catapaste CCP" manufactured by Okuno Pharmaceutical Industry Co., Ltd.) is printed on the side face of a three-layer structure formed of the lower electrode layer 110, the insulating layer 120 and the upper electrode layer 130.

The resultant structure is left as it is for fifteen minutes, and is then annealed at about 200°C for twenty minutes. As a result, as is shown in Fig. 24, an electron emitting film 140 formed of a Pb particulate layer is obtained. In this case, the three-layer structure, which is formed of the lower electrode layer 110, the insulating layer 120 and the upper electrode layer 130, and the electron emitting film 140, which is formed on the side face, constitute an electron emitting device 200, as will be described later.

[0035]

<Operational Principle For Electron Emitting Device>

Finally, an explanation will be given for the operational principle for the electron emitting device 200 (Fig. 24) that is manufactured through the above described processing. Fig. 27 is a side view of the state wherein an opposing substrate 300 is located facing a substrate 100 where the electron emitting device 200 is formed, so that an FED device is provided. As is described above, the electron emitting device 200 includes the three-layer structure (the lower electrode 110, the insulating electrode 120 and the upper electrode 130), formed on the glass substrate 100, and the electron emitting film 140, formed on the side of the three-layer structure. The opposing substrate 300 is obtained by depositing a transparent electrode 320 and a fluophor layer 330 on a glass substrate 310. The transparent electrode 320 is made

of, for example, ITO, and functions as an anode electrode.

[0036]

Consider a phenomenon that occurs when wiring shown in Fig. 27 is provided for the individual sections of the FED device. With this wiring, the lower electrode layer 10 is grounded, and a negative voltage is applied to the upper electrode layer 130 by a power source 410. Further, a cathode/anode voltage is applied to the electron emitting device 200 and the opposing substrate 300 by a power source 420. However, in the state shown in Fig. 27, since a switch 430 is open, a voltage is not applied. When a voltage is applied to both ends of the electron emitting film 140 by the lower electrode layer 110 and the upper electrode layer 130, electron emission occurs on the surface of the electron emitting film 140 as is indicated by an arrow in Fig. 27. This is a phenomenon known as surface-conductive electron emission.

[0037]

When the switch 430 is closed and a cathode/anode voltage is applied, as is shown in Fig. 28, the electrons are emitted to the surface of the electron emitting film 140 and fly to the opposing substrate 300 on the anode side. Due to collisions of the electrons that are flying from the cathode to the anode, the fluophor film 330 emits light. In this case, for the sake of convenience, the component for only one pixel are shown. However, when the component for one pixel is arranged vertically and horizontally in a

matrix shape, a flat panel display where pixels are arranged in two-dimensional plane can be obtained. For such a flat panel display, generally, the switch 430 is maintained closed, and the voltage applied by the power source 410 is adjusted for each pixel to control the light-emitting state for each pixel. More specifically, the value of a voltage applied to the electron emitting film 140 and the voltage application time need only be adjusted, so that the amount of electrons flying to the opposing substrate 300 can be controlled.

[0038]

Fig. 29 is a diagram for explaining the principle for driving a matrix substrate employing the above described electron emitting devices 200. In this example, the electron emitting devices 200 are formed in five rows and in five columns, i.e., the total 24 electron emitting devices 200 are formed. That is, the five lower electrode layers 110, each of which is extended in the direction of columns, are arranged in the direction of rows, while five upper lower electrode layers 130, each of which is extended in the direction of rows, are arranged in the direction of columns, and 25 electron emitting devices 200 are located near the intersections. The electron emission can be independently controlled for the individual electron emitting devices 200.

[0039]

A selector 150 and a driver 160 are provided to

perform such control. The selector 150 has a function for selecting and grounding one of the five lower electrode layers 110, and the driver 160 has a function for transmitting a predetermined voltage signal to the individual five upper electrode layers 130. When the selector 150 selects the five lower electrode layers 110 in order, the five columns can be sequentially accessed in a time-dividing manner. Further, in accordance with a signal transmitted from the driver 160, electrons are emitted by the electron emission devices 200 that belong to the currently accessed column. For example, as is shown in Fig. 29, when the selector 150 selects and grounds the first column, and when the driver 160 applies a negative voltage to the upper electrode layer 130 in the first row, the wiring shown in Fig. 28 is provided for the electron emitting devices in the first row and in the first column, and electrons are emitted to the opposing substrate 20. This driving method is a so-called "simple matrix driving" method.

[0040]

[Advantage of the Invention]

As is described above, according to the method of the invention for forming a layer having a predetermined plane pattern, a paste layer one size larger is formed in advance by printing, and a photolithography method is employed for precise pattern formation. Therefore, a layer having a predetermined plane pattern can be formed while

the waste of the material is avoided as much as possible.

[Brief Description of the Drawings]

[Fig. 1]

This is a cross-sectional view of the state at the first stage of a conventional, common layer formation method employing a paste layer.

[Fig. 2]

This is a cross-sectional view of the state at the second stage of the conventional, common layer formation method employing a paste layer.

[Fig. 3]

This is a cross-sectional view of the state at the third stage of the conventional, common layer formation method employing a paste layer.

[Fig. 4]

This is a plan view of a layer to be formed by a method according to the present invention.

[Fig. 5]

This is a plan view of a paste layer 45 having a pattern P2 that is one size large than a pattern P1 in Fig. 4.

[Fig. 6]

This is a plan view of the state wherein the paste layer 45 in Fig. 5 is exposed.

[Fig. 7]

This is a plan view of the state wherein the paste layer 45 in Fig. 6 that has been exposed is developed.

[Fig. 8]

This is a cross-sectional view of the paste layer 45 that is formed by the method according to the present invention and that has the pattern P2 that is one size larger.

[Fig. 9]

This is a cross-sectional view of the state wherein the paste layer 45 in Fig. 8 is exposed.

[Fig. 10]

This is a cross-sectional view of a first paste layer 51 that is formed by the method according to the present invention, and that has a pattern P2 that is one size larger.

[Fig. 11]

This is a cross-sectional view of the state wherein a second paste layer 52 is additionally formed on the first paste layer 51 in Fig. 10.

[Fig. 12]

This is a cross-sectional view of the state wherein the paste layers 51 and 52 in Fig. 11 are exposed.

[Fig. 13]

This is a plan view of the state wherein the exposed paste layers 51 and 52 in Fig. 12 are developed.

[Fig. 14]

This is a plan view of the state wherein a second paste layer 53 having a small area is formed on the first paste layer 51.

[Fig. 15]

This is a cross-sectional view of the state wherein the paste layers 51 and 53 in Fig. 14 are exposed.

[Fig. 16]

This is a perspective view of the first stage of the electron emitting device formation processing according to a first embodiment of the present invention.

[Fig. 17]

This is a perspective view of the second stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 18]

This is a perspective view of the third stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 19]

This is a perspective view of the fourth stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 20]

This is a perspective view of the fifth stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 21]

This is a perspective view of the sixth stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 22]

This is a perspective view of the seventh stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 23]

This is a perspective view of the eighth stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 24]

This is a perspective view of the final stage of the electron emitting device formation processing according to the first embodiment of the present invention.

[Fig. 25]

This is a perspective view of the fourth stage of the electron emitting device formation processing according to a second embodiment of the present invention.

[Fig. 26]

This is a perspective view of the fifth stage of the electron emitting device formation processing according to the second embodiment of the present invention.

[Fig. 27]

This is a cross-sectional view for explaining the operating principle for the electron emitting device manufactured in the first or the second embodiment of the present invention.

[Fig. 28]

This is another cross-sectional view for

explaining the operating principle for the electron emitting device manufactured in the first or the second embodiment of the present invention.

[Fig. 29]

This is a plan view for explaining the operating principle for a matrix substrate wherein the electron emitting devices, manufactured in the first or the second embodiment of the present invention, are arranged in a matrix shape.

[Description of the Reference Numerals and Signs]

10: substrate

20: paste layer

20a: exposed portion

20b: non-exposed portion

30: photomask

40: layer having plane pattern P1

45: paste layer

45a: exposed portion

45b: non-exposed portion

51: first paste layer

51a: exposed portion

51b: non-exposed portion

52: second paste layer

52a: exposed portion

52b: non-exposed portion

53: different, second paste layer

53a: exposed portion

53b: non-exposed portion

100: glass substrate

105: preparation layer

110: lower electrode layer

120: insulating layer

125: preparation layer

130: upper electrode layer

135: preparation layer

136: preparation layer

140: electron emitting film

150: selector

160: driver

200: electron emitting device

300: opposing substrate

310: glass substrate

320: transparent electrode

330: fluophor layer

410, 420: power source

430: switch

d: distance between the outer edges of both patterns

M: photomask

P1: plane pattern to be formed

P2: expanded pattern